Laboratories for the 21st Century

Modeling Session E-3

LABS FOR THE 21ST CENTURY

October 7-9-2002

Flad & Associates

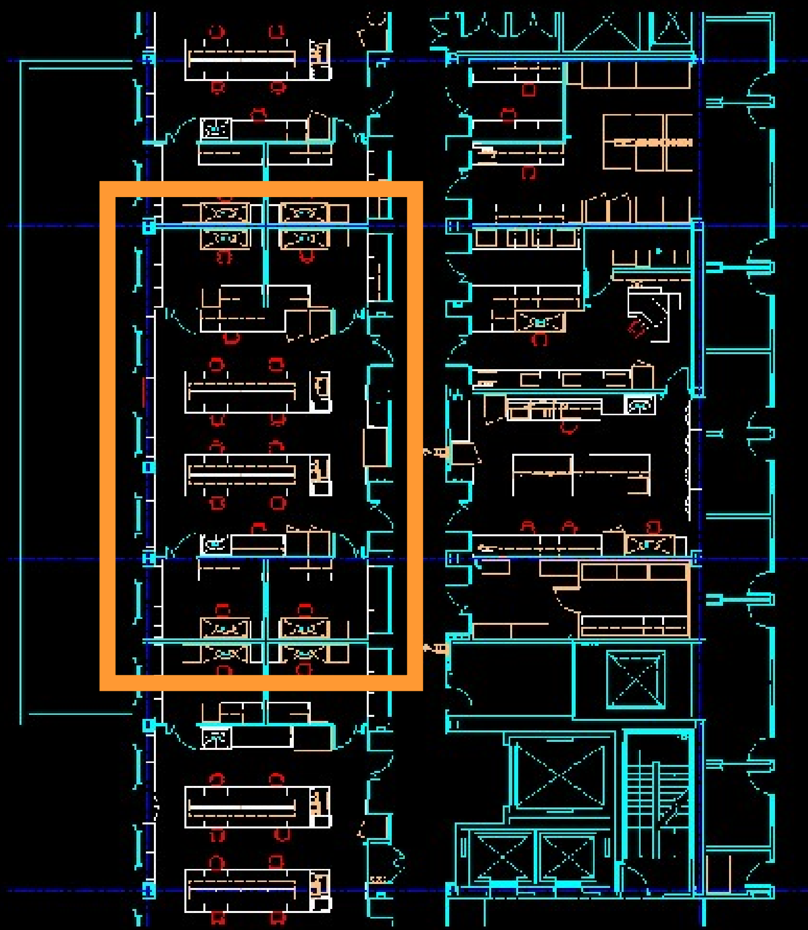
Affiliated Engineers

Fluent, Inc.

Wyeth Research and Development Laboratory--B260

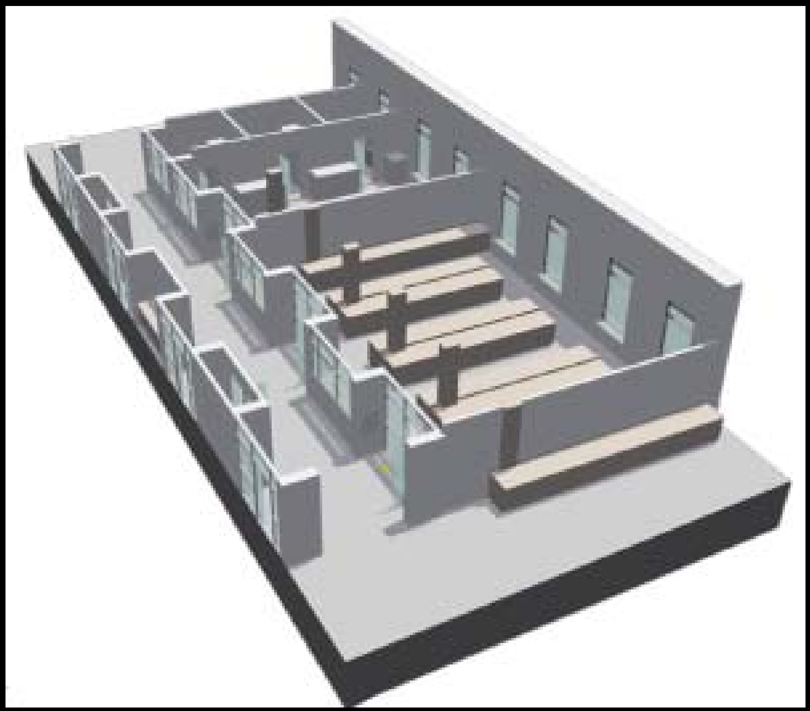
- 175,000 gsf facility for 277 people
- Bacterial research
- Viral research
- Immunology

Typical Immunology Labs



- 11’ x 32’ planning module
- 1,056 square foot laboratory
- 176 square foot isolation rooms (4)
- 1760 square foot lab suite
- 9’-8” ceiling height

Strategies to Reduce Ventilation Energy Consumption

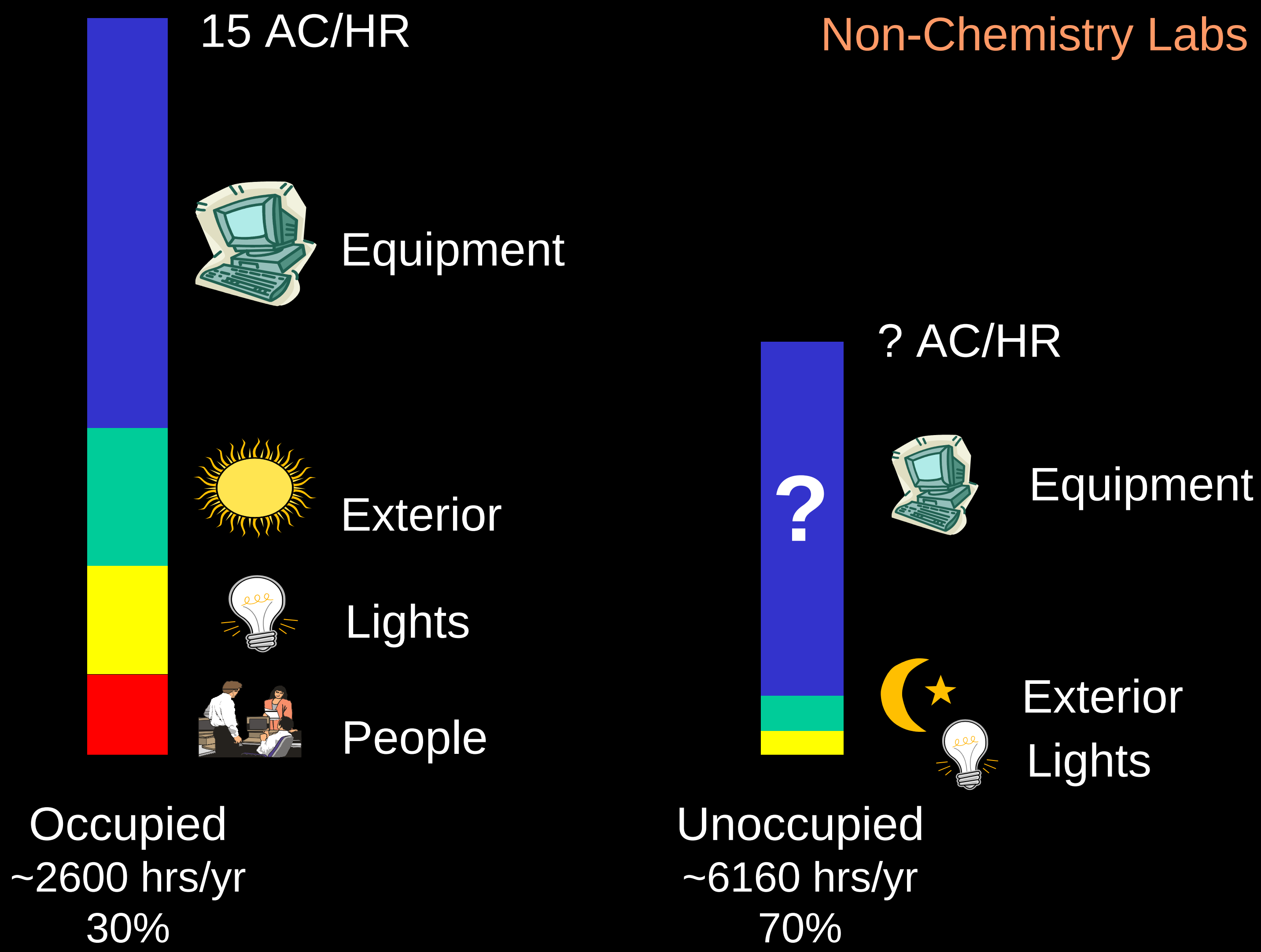


- Vary airflow based on actual use
- **Determine minimum airflow rate**
- Reduce system pressure drop
- Improve fan system efficiency

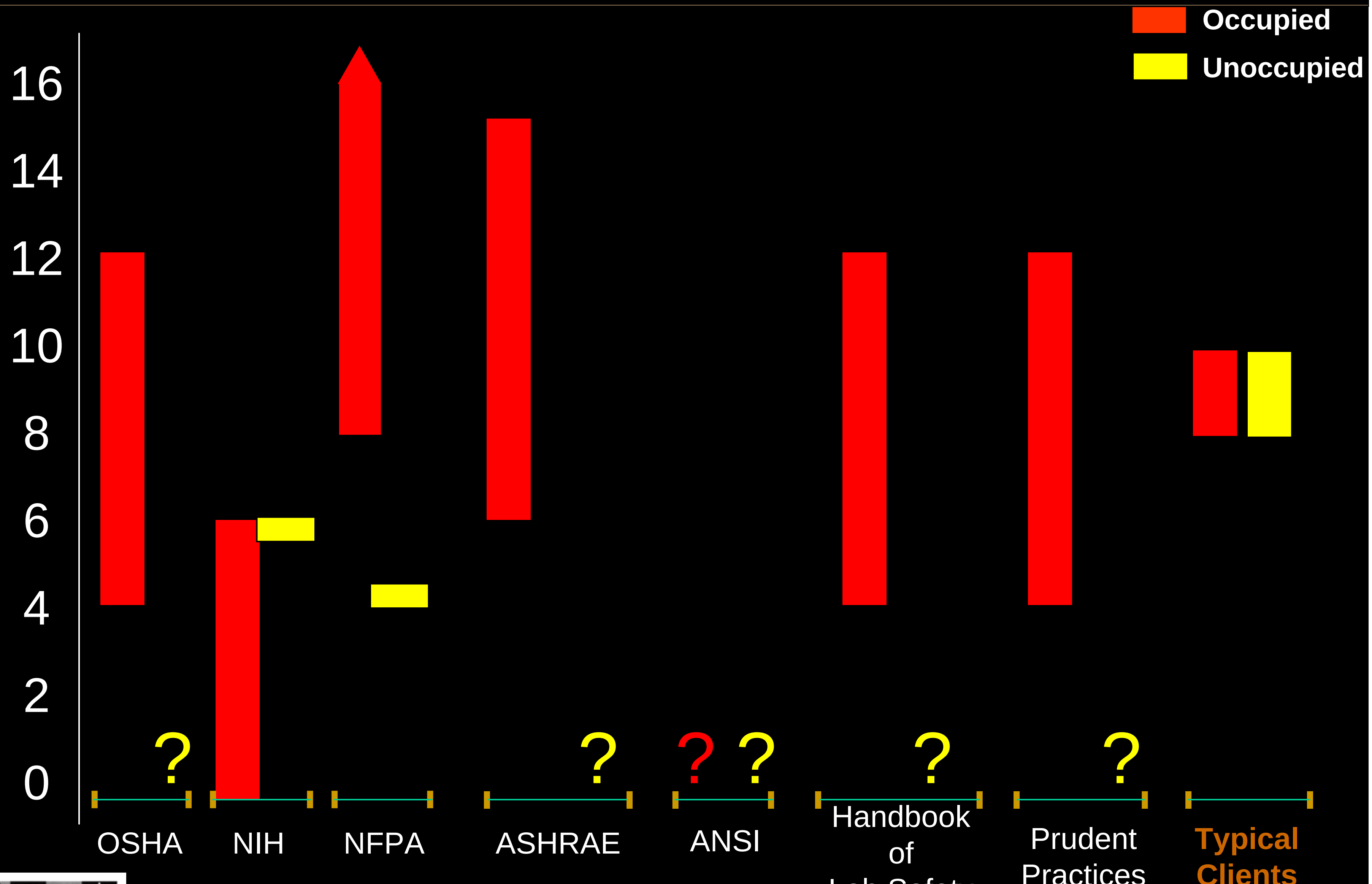
How Amount of Air is Determined

- Need – the thermostat
- Need – connected equipment – hoods
- Code
- Historical intuition

Air Changes / Hour



Guidelines for Minimum Air Changes / Hour in Non-Chemistry Laboratories



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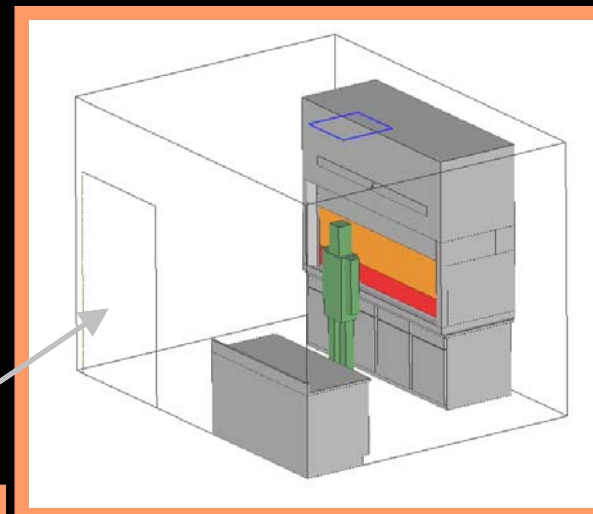
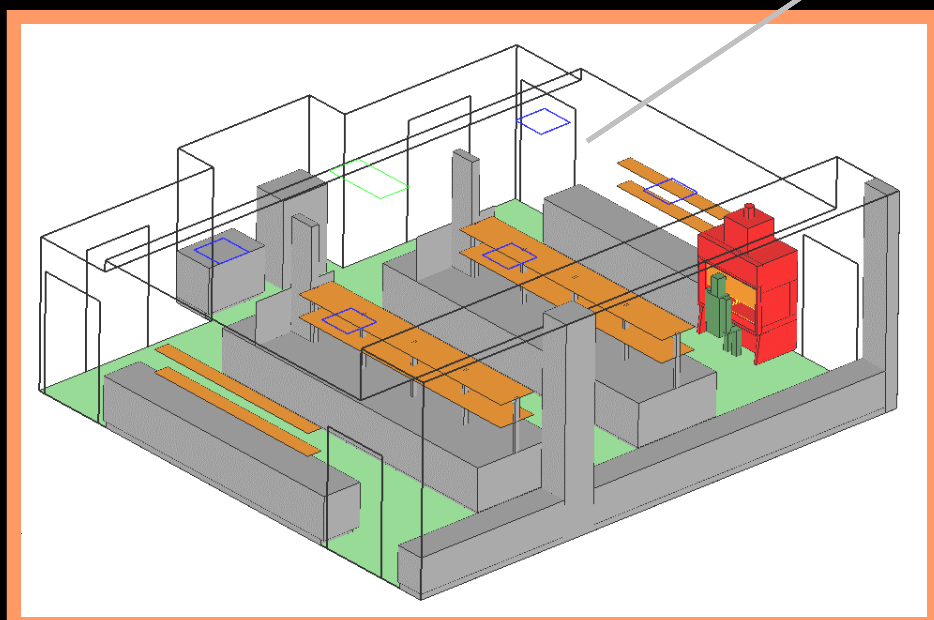
Building a Laboratory Airflow Model

3D DXF CADD file imported as basis for airflow model

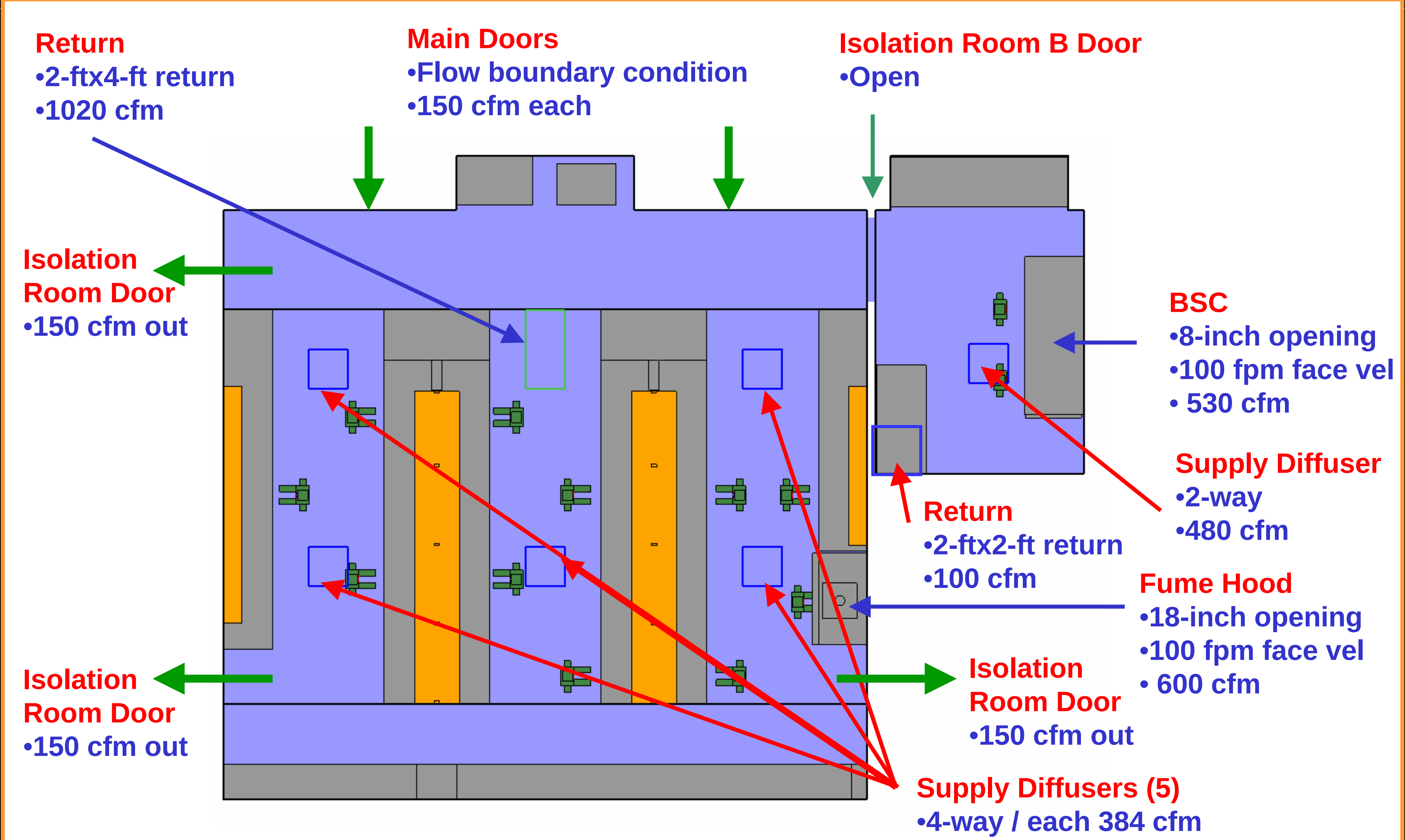


Isolation Room B

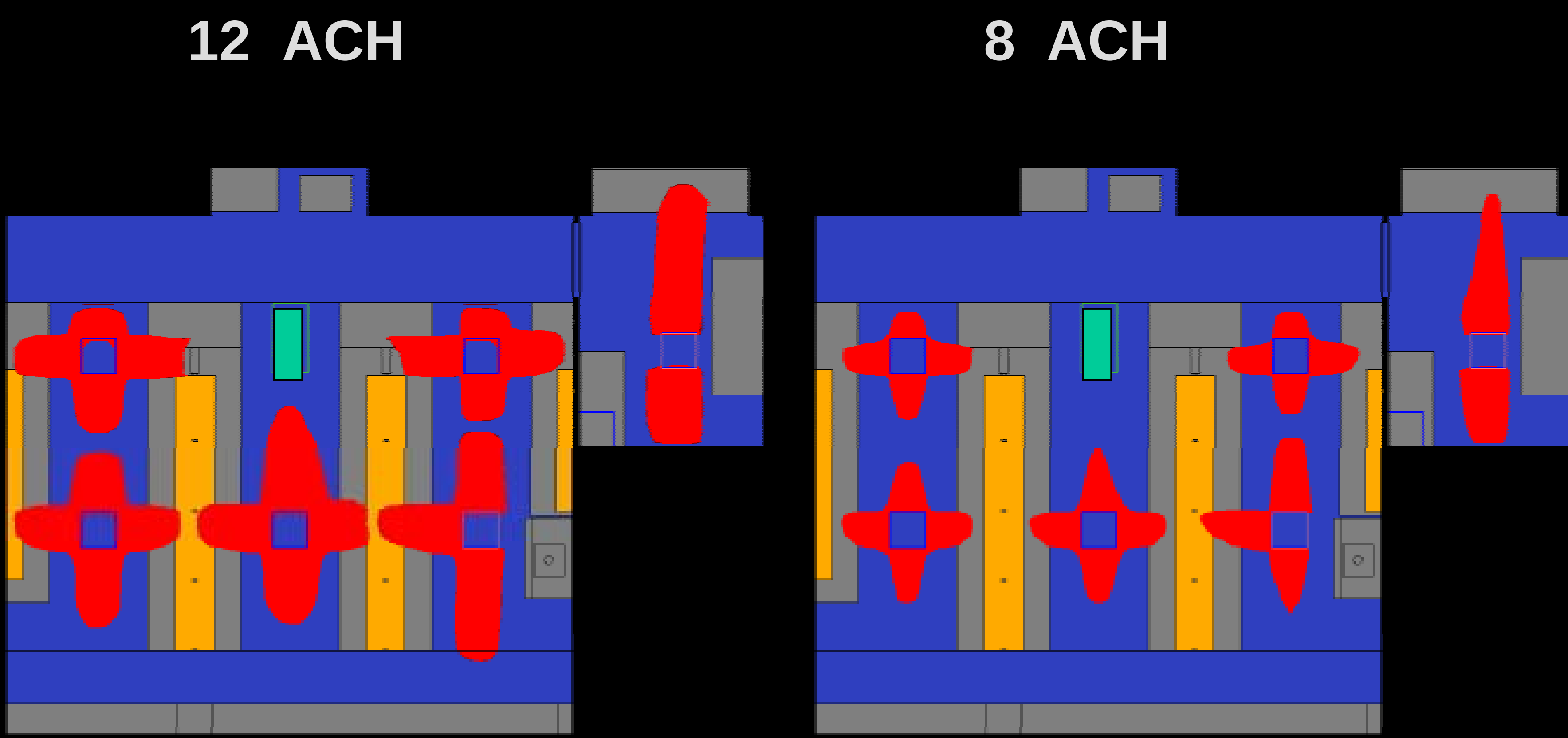
Central Laboratory Space



Laboratory Ventilation Flow Rates – 12 ACH



Supply Airflow Patterns From Ceiling Diffusers

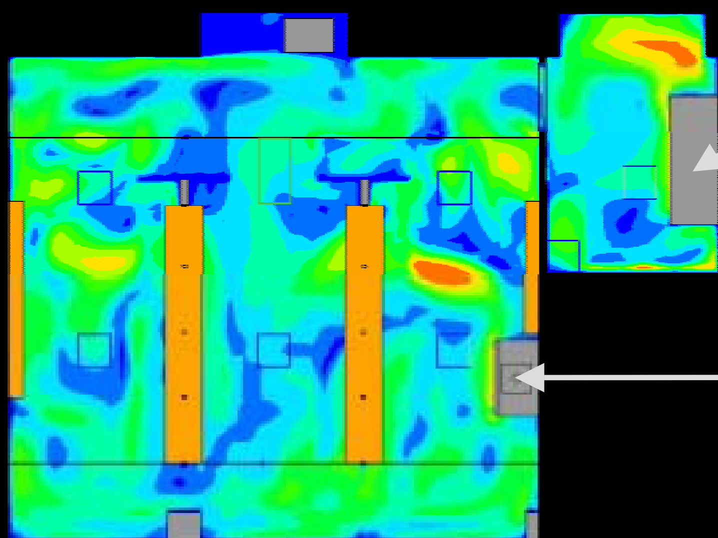


Iso-surfaces of 150 fpm air velocity

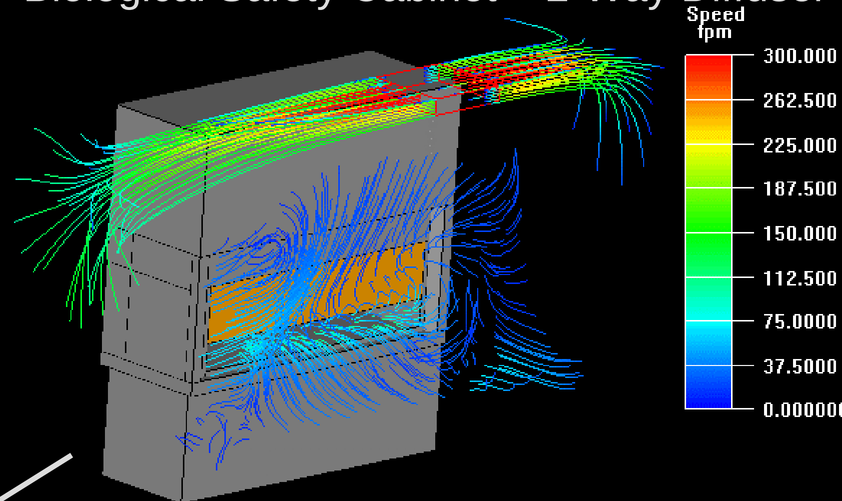
Will Ventilation System Design Affect Hoods?

- Want to avoid supply air interfering with hood capture efficiency
- Possible problem if supply jet with air velocity > 50% of face velocity (~100 fpm) reaches sash opening
- Maximum supply airflow shown here: 18 ACH

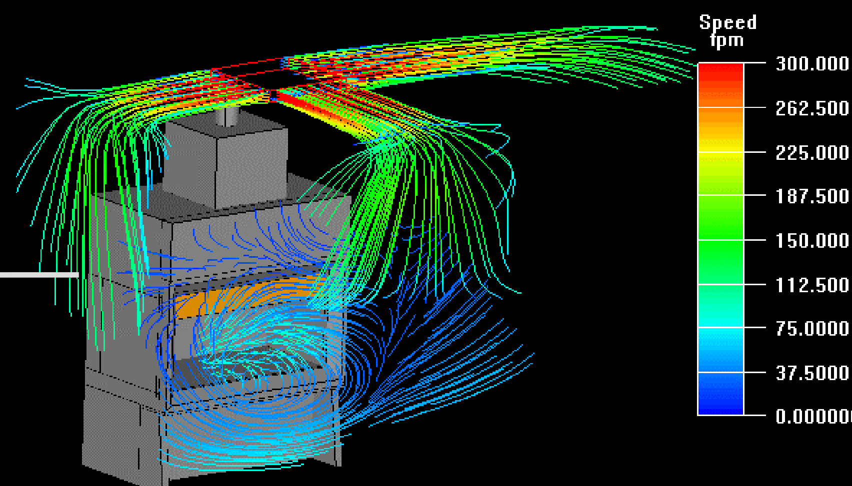
Air velocity contours at z = 1 m



Biological Safety Cabinet + 2-Way Diffuser



Fume Hood + 3-Way Diffuser



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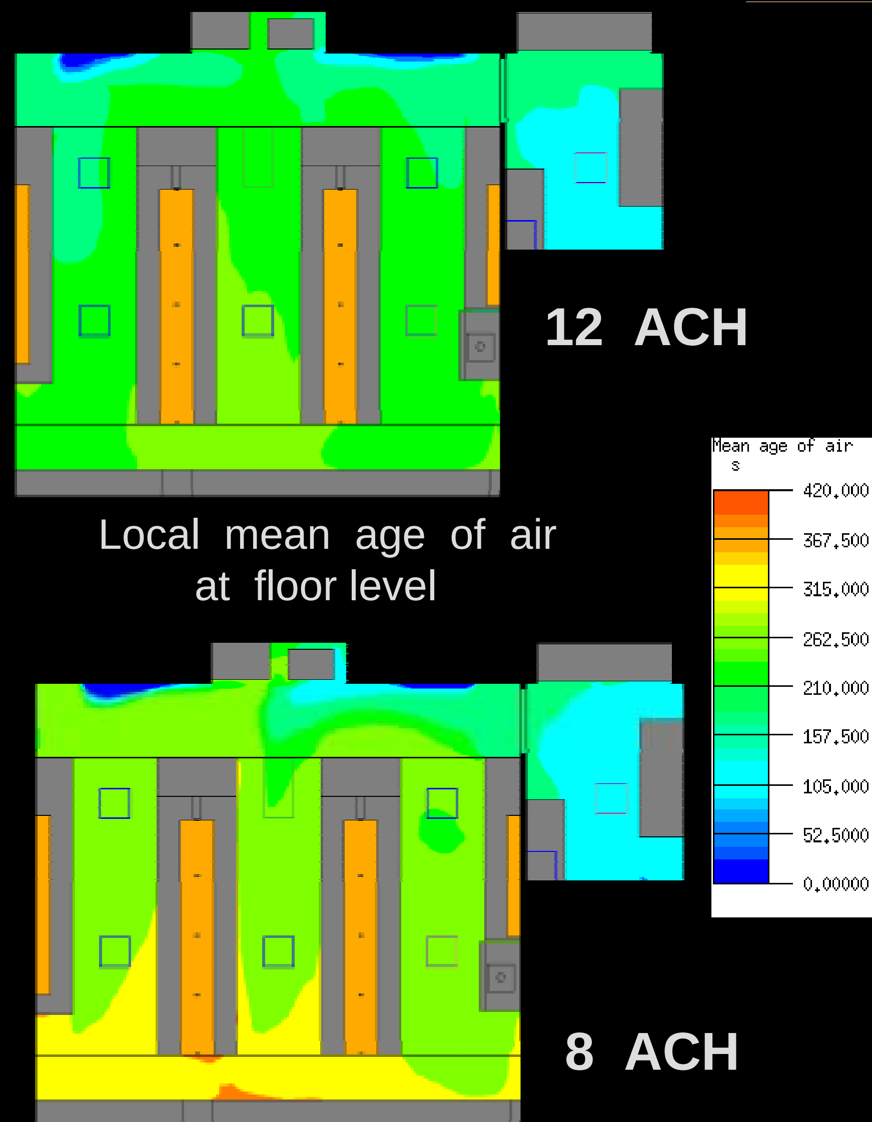
Ventilation Effectiveness is Important

- Airflow modeling can determine the local mean age of air , τ
  - Represents freshness of the air or expected turnover
  - Can be used to identify poorly ventilated areas
- Ventilation effectiveness, η related to mean age of air, τ

$$\eta = \frac{3600/\mathrm{ACH}}{\tau}$$

- Average ventilation effectiveness in occupied zone should be > 0.9



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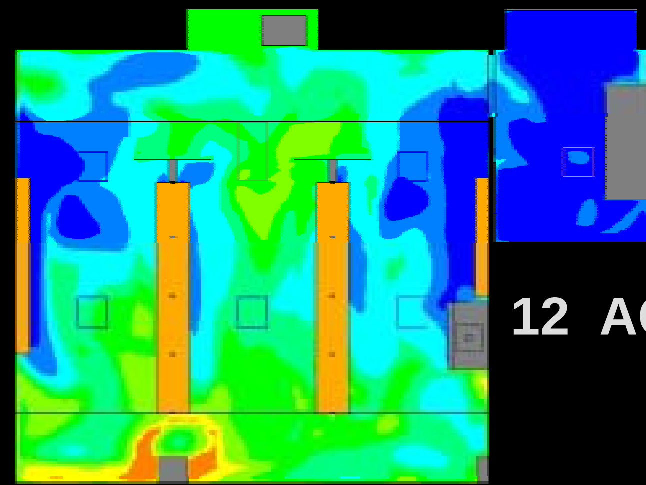
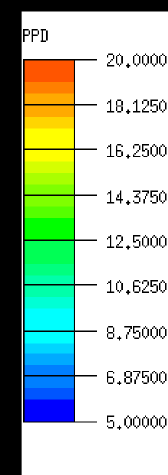
Determine if Thermal Comfort Achieved

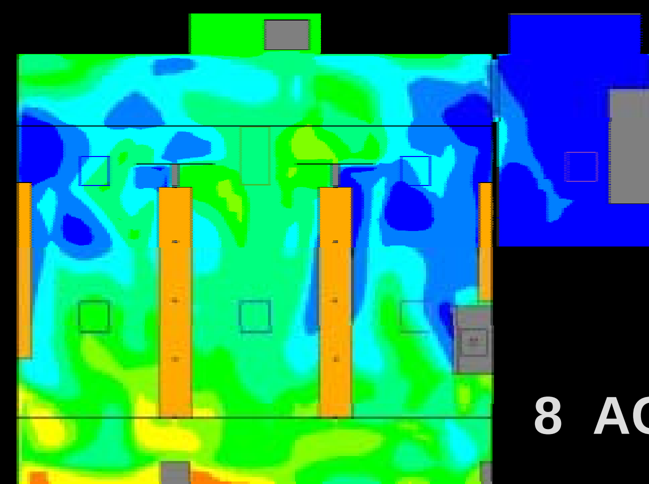
- Predicted thermal comfort of workers is a function of
  - Assumptions
    - Clothing
    - Activity level (metabolic rate)
  - Local conditions
    - air velocity
    - air temperature
    - relative humidity
    - mean radiant temperature
- Airflow modeling can compute local conditions and predict thermal comfort
  - Predicted Mean Vote (PMV)
  - Percent of People Dissatisfied (PPD)



12 ACH

Percentage of People Dissatisfied (PPD) at z = 1 m





8 ACH

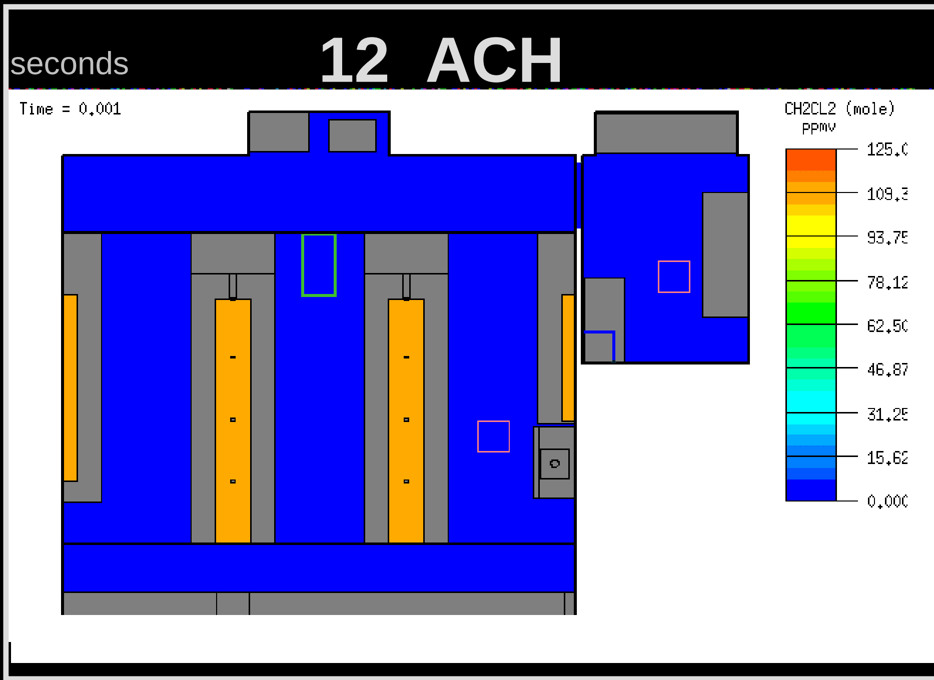
Energy Performance and Laboratory Safety

- Want to optimize laboratory energy performance by allowing for reduced ventilation flow rates when thermal loads permit it
- Use airflow modeling to help determine if laboratory will provide safe environment for workers in the event of chemical spill scenario
  - 1-liter spill of methylene chloride in isolation room
  - 4-liter spill of methylene chloride in central laboratory area
  - Acceptability criteria:
    - MeCl concentration does not exceed 125 ppmv (STEL) for more than one hour
      - Although OSHA STEL is 125 ppmv for 15 minute average, assume laboratory is evacuated by unprotected personnel shortly after spill occurs

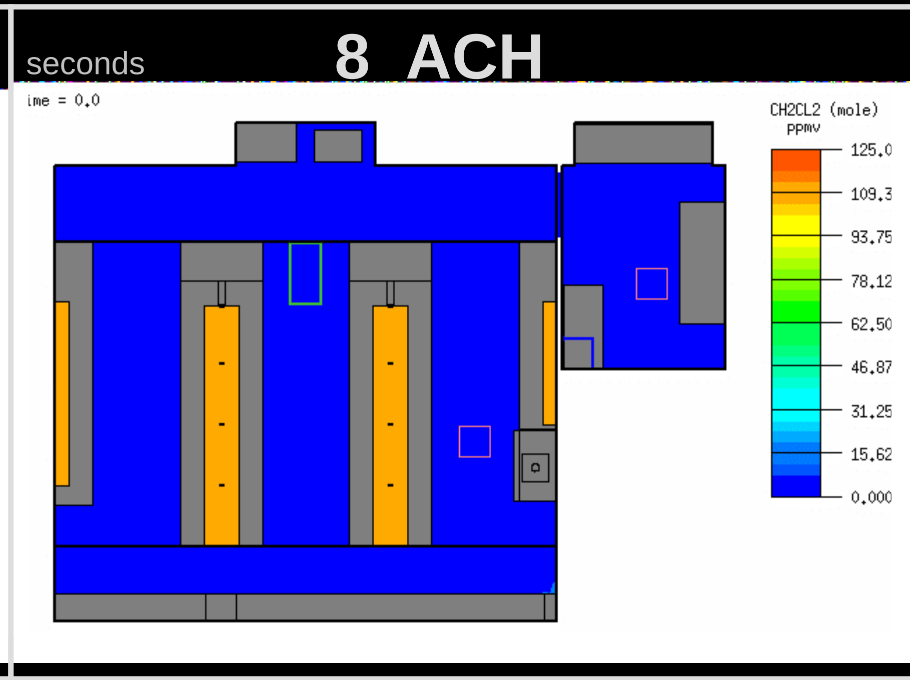
Transient Floor Concentration Levels for Small Spill

- 1-liter liquid methylene chloride spill in isolation room
- 1 m^2 spill area
- Vaporization occurs over 300 seconds at constant rate
- Total simulation time = 1,800 seconds

color contours clipped at 125 ppmv



concentration drops below 125 ppmv at 840 s



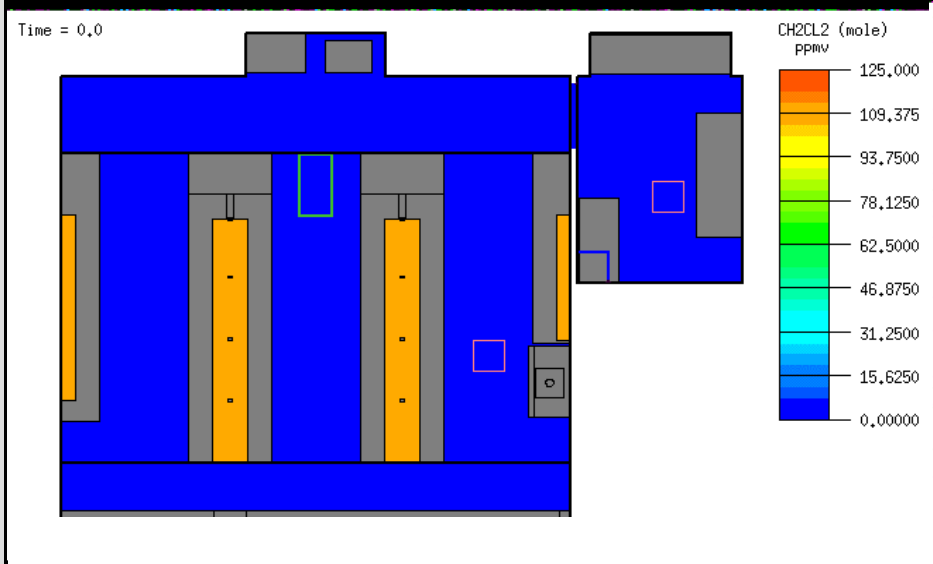
concentration drops below 125 ppmv at 1140 s

Transient Floor Concentration Levels for Large Spill

- 4-liter liquid methylene chloride spill in central laboratory
- 4 m^2 spill area
- Vaporization occurs over 300 seconds at constant rate
- Total simulation time = 3,600 seconds

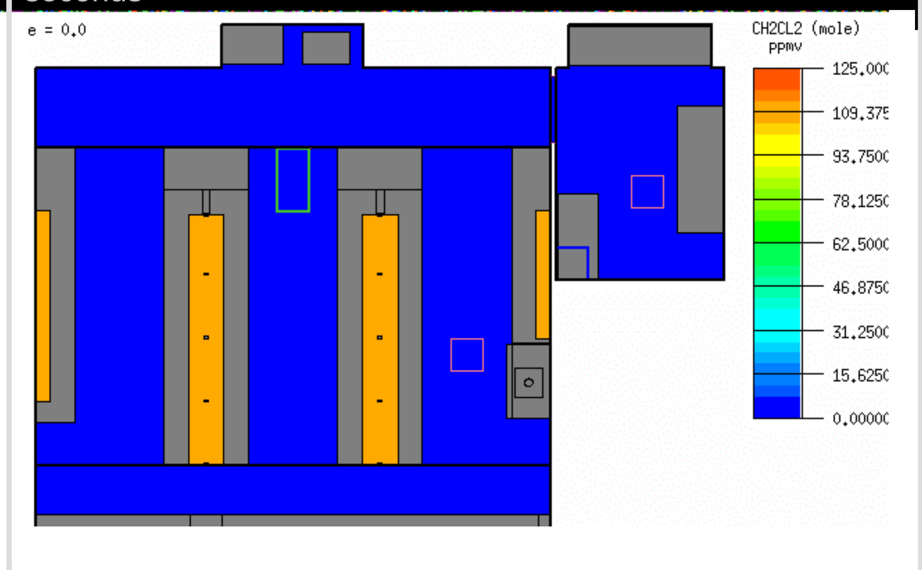
color contours clipped at 125 ppmv

seconds **12 ACH**



concentration drops below 125 ppmv at 1560 s

seconds **8 ACH**



concentration drops below 125 ppmv at 1680 s

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Labs 21 EPC Modification Criteria for ASHRAE 90.1

	Budget Building Design	Proposed Design
	Same as proposed design	Based on prerequisite 4
	Same as proposed design	Based on laboratory requirements and operation
	1.8 W / sf (net)	As designed
	100 fpm face velocity with vertical rising sash 18” open	As designed
	100% outside air, constant volume, without heat recovery	As designed, using same occupied hours schedule as budget design

All other characteristics of the budget building design and proposed design (e.g. envelope, etc.) shall remain the same as in the standard

DOE2 Energy Simulation Baselines

- New York State Energy Conservation Code
- New York State Energy Research and Development Authority (NYSERDA) New Construction Program
- ASHRAE / IESNA Standard 90.1 – 1999 (LEED)
- Labs21 Environmental Performance Criteria (EPC)

DOE2 Analysis

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : PEARL RIVER N.Y.
MODEL DESCRIPTION : ASH99: ASHRAE 90.1, 1999

REPORT-1: ANNUAL ENERGY USE STATISTICS

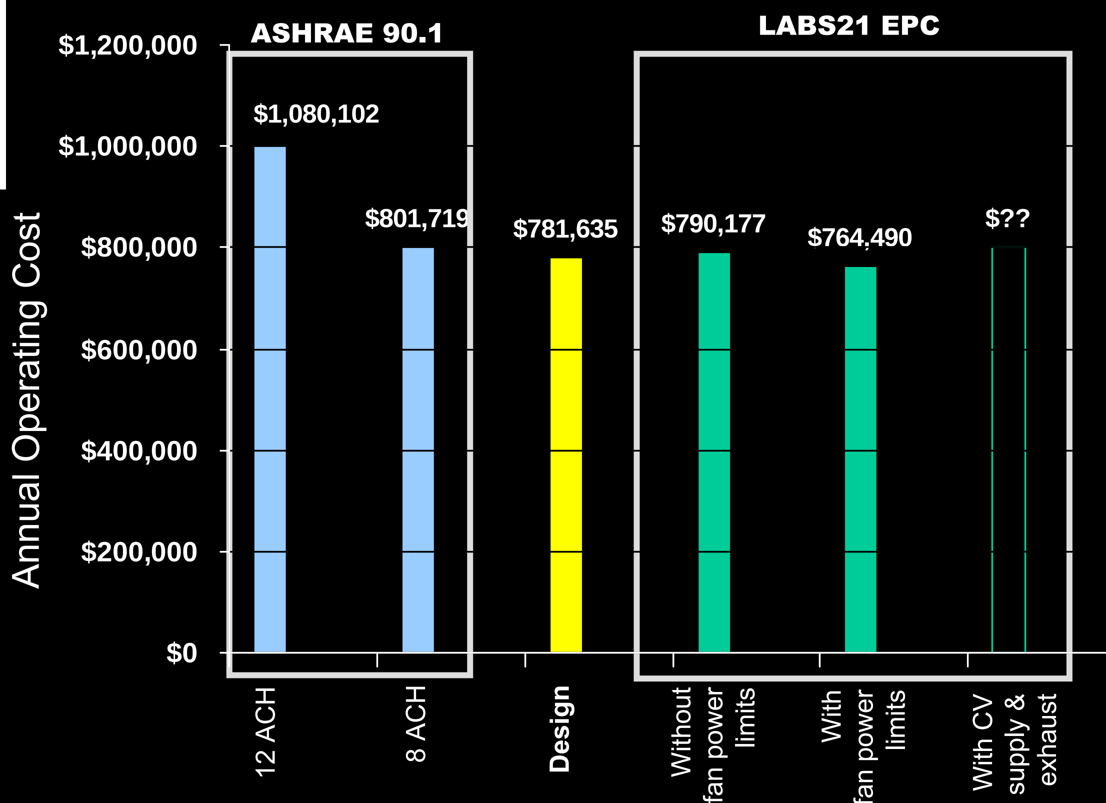
FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	0	0	0	1619687	368703	0	900429	3955603	32194	6876616
STEAM (MMBTU)	425032	0	0	0	0	0	0	0	0	46044
CHILLED WATER (TON-HR)	0	1400120	0	0	0	0	0	0	0	1400125

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	C. WATER TON-HR	C. WATER BILL ($)	STEAM MMBTU	STEAM MMBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	574135	1280	55580	0	0	5866	305	6519	146	47921	103806
FEB	518889	1282	50641	0	0	5788	301	5989	145	44022	94964
MAR	580576	1278	56159	0	0	5649	294	5718	123	42029	98482
APR	569791	1296	55250	0	0	41904	2181	3511	93	25807	83238
MAY	576231	1298	55816	0	0	145539	7573	2461	79	18092	81481
JUN	580354	1327	56871	0	0	228219	11876	1961	46	14421	83168
JUL	598055	1334	58474	0	0	311503	16210	1839	39	13517	88201
AUG	589349	1323	57651	0	0	291171	15151	1904	40	13994	86796
SEP	578383	1305	56616	0	0	211238	10992	2059	80	15139	82747
OCT	580807	1293	56218	0	0	121118	6303	2812	92	20672	83193
NOV	547132	1285	53170	0	0	17153	893	5273	124	38758	92821
DEC	582711	1287	56377	0	0	14973	779	5993	144	44051	101207
TOTAL	6876616	1334	668822	0	0	1400125	72857	46044	146	338423	1080102

Courtesy of Steven Winter Associates

- Comparison of 8 vs. 12 ACHs yielded a $280,000 annual operating savings
- Modeled ASHRAE 90.1 – 1999 and draft version of LABS 21 EPC



Questions / Discussion

Garrick Maine, AIA, Flad & Associates

As an advocate of environmental design Garrick is Flad's representative to the U.S. Green Building Council, the Wisconsin Green Building Alliance and member of the Board of Directors of WasteCap Wisconsin, a non-profit organization promoting responsible waste management practices.

Steven G. Frei, PE, Affiliated Engineers

Mr. Frei has extensive experience designing mechanical systems for research and testing facilities. This experience includes the design of new facilities and renovation of existing structures.

Walter Schwarz, Fluent Inc.

Walter Schwarz has over 20 years of experience in the areas of flow modeling, heat transfer, and turbulence. He is currently working on delivering airflow modeling solutions to the HVAC industry related to ventilation system performance with respect to indoor air quality, thermal comfort, health and safety, and contamination control.